THE CORRELATION BETWEEN SOME PHYSICAL CHARACTERS OF THE BEE AND ITS HONEY-STORING ABILITIES[1]

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It has long been known that some colonies in a beeyard exceed others in the amount of honey they store. As a remedy for this condition, it has been urged to have all the colonies strong before the honey flow begins and to have them as nearly the same strength as possible. Yet, even when this advice has been followed, bees of the same race, raised from queens of the same age and strain, differ in the amount of honey that they store. In an attempt to learn why these facts exist, the following experiment is being conducted at this station.

During the summer of 1920, four colonies of bees, numbered 5, 6, 7, and 8 respectively, were selected to be used for this experiment. In 1921, the number of colonies used was increased to six and numbered 1, 2, 3, 4, 5, and 6. During both years the colonies selected were nearly equal in strength, the queens used were of the same age, and raised by the same breeder. Throughout both summers the same manipulations were made with each colony.

At the beginning of the summer the exact number of bees, the amount of honey in each hive, and the amount of brood were determined by a system of weighing. In July, 1921, a mid-season weighing was made before the main honey flow ended. In the fall of the year another weighing was made to ascertain the total amount of honey that had been stored in each colony during the season.

Collections were made daily of ten bees returning to each hive, and when possible a second collection was made during the day. These bees were then taken to the laboratory where the tongue (glossa) of each was measured, the amount of nectar in its stomach was weighed to determine its carrying capacity, and then the weight of the bee, together with its empty honey stomach and tongue was determined. During 1920, bees filled with nectar returning from the field were collected, and the nectar was weighed. Since nectar from different plants varies in specific gravity, it was decided in 1921 to allow the bees to digest the nectar which they had brought in, and then feed them with a sweetened solution of standard strength. During the summer of 1920, 2880 bees were examined and the results recorded. It was found that

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[1]Contribution No. 74, from the Entomological Laboratory, Kansas State Agricultural College. This paper embodies some of the results obtained in the prosecution of project No. 126 of the Agricultural Experiment Station.

there was a distinct correlation between certain physical characters of the bee and the amount of honey stored. This is shown in the following table.

TABLE I.—COMPARISON OF SOME PHYSICAL CHARACTERS AND THE TOTAL AMOUNT OF HONEY STORED DURING 1920

Hive number	5	6	7	8
No. of bees in spring	4th 12,500	2d 19,375	1st 20,000	3d 18,750
Length of tongue	4th	2d	1st	3d
Weight of bee	3d	2d	1st	4th
Carrying capacity	4th	1st	2d	3d
Total honey stored in pounds	3d 61⅜	1st 116⅜	2d 74½	4th 53⅜

Some of the significant facts brought out by this table are: First, the bees which have the longest tongues, the largest bodies, and the greatest carrying capacity are also the ones which form the strongest colonies in the spring. This fact will be emphasized when the results of 1921 are examined. It will be noticed that the colonies possessing the longest tongues, greatest bodies and largest carrying capacity exceed in the total amount of honey stored.

Colony No. 6, which ranked second in number of bees in the spring, second in length of tongue, and second in weight of bee, ranked first in the total amount of honey stored. Colony No. 7 ranked first, although it was approximately equal to colony No. 6 in the number of bees in the spring; was first in length of tongue, first in weight of bee, but was second in its carrying capacity and was second in the total amount of honey stored.

The following table shows the same results for 1921.

TABLE II.—COMPARISON OF THE CARRYING CAPACITY AND STORING ABILITY

Hive number	1	2	3	4	5	6
Total honey produced in pounds	4th 56⅝	6th 16½	1st 119½	2d 82½	3d 68⅜	5th 43
Carrying capacity in mg.	4th 19.59	5th 18.67	1st 21.63	2d 20.05	3d 19.89	6th 18.64

The above table shows a comparison of the total amount of honey stored in each hive and the average carrying capacity of the bees in those hives. The relative rank is indicated by the figures placed above the results. The colonies whose bees had the largest individual carrying capacity are the ones which stored the greatest amount of honey, and for the four highest there appears to be a direct correlation between the carrying capacity and the total amount of honey stored

during the entire season. The results of the 1921 season confirm those obtained in 1920, since the colonies which ranked first, second, third and fourth in carrying capacity also ranked first, second, third and fourth in the amount of honey produced. In 1920, the colonies that ranked first and second in the individual carrying capacity, also ranked first and second in the total amount of honey stored.

As the season of 1921 was the second during which this experiment has been conducted, naturally more data were collected than during the first year. The following table summarizes some of the most striking results obtained during the second year of this work.

TABLE III.—COMPARISON OF SOME PHYSICAL CHARACTERS AND AMOUNT OF HONEY STORED DURING 1921

Hive number	1	2	3	4	5	6
No. bees in hive June 15	5th 23,740	3d 35,625	1st 42,500	4th 25,000	2d 40,000	6th 17,500
Honey stored between June 15 & July 15, in pounds	3d 62½	5th 29⅛	1st 85⅜	4th 55⅜	2d 79	6th 24⅞
Average length of tongue in mm.	6th 3.57	3d 3.62	1st 3.86	4th 3.61	2d 3.84	5th 3.59
Average weight of bee in mg.	5th 82.1	3d 86.1	1st 93.6	4th 84.6	2d 86.5	6th 70.6
Carrying capacity in mg.	4th 19.59	5th 18.67	1st 21.63	2d 20.05	3d 19.89	6th 18.64
Total honey produced in pounds	4th 56⅝	6th 16¾	1st 119½	2d 82¼	3d 68⅜	5th 43

These hives were kept on platform scales throughout the season, and a record was made of the daily changes in weight, which indicated whether or not nectar was being brought into the hives. These records show that the main honey flow stopped on July 28, or 13 days after the mid-season weighing was made. Some very interesting facts were brought out by a study of the data, comparing the length of tongue, the weight of the bee, the number of bees which were in the hive on June 15, and the amount of honey stored during the heaviest part of the honey flow. Hive No. 3 was first in all of these respects; hive No. 5 was second, and hive No. 4 was fourth. Hive No. 2, which was third in number of bees on June 15th and third in length of tongue and the weight of the individual bee, drops to fifth place in its carrying capacity and also to fifth place in amount of honey stored between June 15 and July 15, and was sixth in rank in the total amount of honey produced for the season. Colony No. 2 and colony No. 6 were practically equal in carrying capacity and ranked sixth and fifth respectively in the total amount of honey produced. Colony No. 1, which was fifth in the number of bees, sixth in the length of the tongue, and fifth

in average weight, rose to fourth in carrying capacity, and stored the third largest amount of honey between June 15 and July 15, but was fourth in the total honey produced, which rank corresponded with its carrying capacity. Colony No. 3 exceeded all others in all of the factors here considered, and stored by far the largest amount of honey during the season. Colony No. 4 was fourth in the number of bees, fourth in the amount of honey stored between June 15 and July 15, and fourth in the length of tongue, fourth in the weight of the bee, but rose to second rank in carrying capacity and total honey produced. Colony No. 5 was second in number of bees, second in honey stored between June 15 and July 15, second in length of tongue, almost equalling colony No. 3, which ranked first in this respect; was second in the weight of the bee, but had a slightly smaller carrying capacity than colony No. 4 which ranked second in carrying capacity and total honey produced, and colony No. 5 ranked third in both of these respects. Colony No. 6 ranked sixth in every feature, except in the length of tongue and total honey produced. Its tongue length and carrying capacity were very nearly equal to that of colony No. 2, which ranked fifth in total honey produced.

These results seemed to indicate that the bees which have the longest tongues, largest bodies and greatest carrying capacities exceed, in the total amount of honey stored, those possessing these factors in a lesser degree. While there seems to be a direct relation between the length of tongue, the size of the bee when the carrying capacity is either equal or about equal, and the total amount of honey stored, yet a study of colony No. 1 would indicate that if it were deficient in the size of tongue and the size of bee, this disadvantage would be offset by the advantage of a larger carrying capacity, because, as previously mentioned, colony No. 1 ranked sixth in the length of tongue and fifth in size of bee, but in its carrying capacity it very nearly equalled colony No. 5 which ranked third in carrying capacity, and on July 15 colony No. 1 ranked third in the amount of honey stored, and at the end of the season ranked fourth in total honey produced. This is again shown in a study of colony No. 4 which ranked fourth in length of tongue and weight of bee, but second in carrying capacity and total amount of honey stored.

During both 1920 and 1921, those colonies whose bees possessed the longest tongues and had the greatest size or carrying capacity, were also strongest in the number of bees. This may be due to the fact that the length of the bee's life depends upon how rapidly its energy is expended. If the bees possessing the longest tongues, the largest size, and the greatest carrying capacities expend less energy to bring in

nectar, this may account for the fact that the bees in these colonies have longer lives and consequently are found in greater numbers.

In 1921, over 3000 bees were examined to determine the length of tongue, the individual carrying capacity, and the size of each bee. The data secured was arranged in frequency distributions and the coefficient of variability was determined from these distributions. This represented the probable variability of the group expressed on the percentage basis. The coefficient of variability in the size of the carrying capacity was larger than either of the other two characters. Consequently, in order to determine the number of individuals necessary to be examined to arrive at a definite conclusion, these figures will be based on the coefficient of variability for the carrying capacity. If ten percent is used as the difference to be measured, then the number of individuals required would be 32. In order to further safeguard these measurements, it seems advisable to examine 40 bees from each colony, as it appears that this number would be sufficient to be fairly representative and to give data accurately sufficient to form a definite conclusion.

SUMMARY

A study of the data obtained in this experiment both in 1920 and 1921 indicates, first that there is a distinct correlation between the length of tongue, carrying capacity of the bee, and the amount of honey stored during the season; Second, that there is a distinct relation between the number of bees found in the colony in the spring and the size of the above named physical characters. Third, it is very strongly indicated that while it would be distinctly advantageous to a bee to excel in all three of its physical characters, yet if it is deficient in any of these characters, the disadvantage may be overcome if it possesses one of the other characters to a greater degree. Since the probable error for the coefficient of variability of each of these physical characters has been computed, it will be necessary to examine 40 bees from any colony in order to determine which colony of bees in a beeyard should be the best producer. As this examination can be made early in the spring, it will enable queen breeders to save one year's time in selecting the colony which they are going to choose for the best producing quality.

TIME AND LABOR FACTORS INVOLVED IN GATHERING POLLEN AND NECTAR

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TIME FACTORS

Individual bees were marked and records kept of the time of departure and return of each marked bee. Observations began early each morning and continued without interruption until the bees ceased

flying at night. During most of the time there were two observers, so that the chances for a marked bee to pass unnoticed were reduced to a minimum. Only full strength colonies were used in securing data.

Nectar Gathering

Since honeyflow and weather conditions have such a direct influence upon the gathering of nectar, the time records secured under any given set of conditions are not likely to be duplicated except under similar conditions. During the period of observation in 1920, average colonies stored about five pounds per day from white sweet clover, *Melilotus alba*, while in 1921, average colonies gained only a little over one pound per day from the same source. Weather conditions were highly favorable for honey production in the former instance but were only fair in the latter. Summarizing, it may be said that one set of data was secured under very favorable conditions, whereas, the other was obtained under conditions which were from mediocre to poor. The data for field trips, hive stays and round trips have been plotted as frequency curves in which the records obtained under favorable and unfavorable conditions are compared.

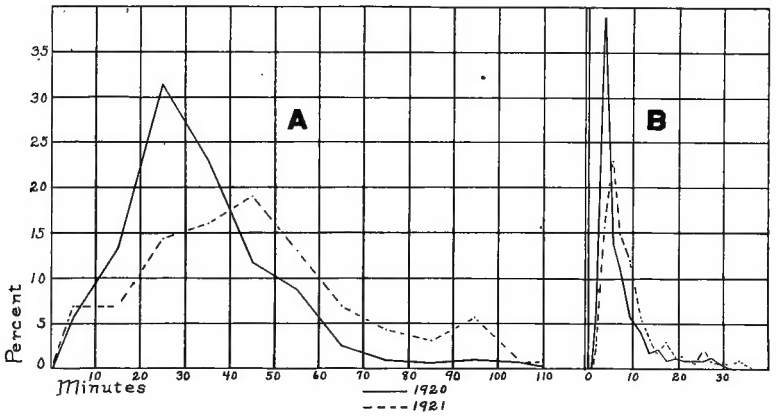

Fig. 3. Showing the frequency distribution of time records made by nectar carriers under *favorable* and *unfavorable* honeyflow conditions. A, Field trip records. B, Hive stay records.

Of the records obtained for field trips made by nectar carriers in 1920, 31 percent fell within the 21-30 minute class, as shown in Fig. 3, A. About 68 percent fell between 10 and 40 minutes, and 95 percent occupied less than 1 hour. The mean time was about 34 minutes but the modal or most frequent interval spent in the field was 26.8 minutes.

[1]Modal values have been determined by use of W. I. King's formula given in his "Elements of Statistical Method," p. 124.

In 1921, only 19 percent of the field trip records fell within the 41-50 minute class in which the peak of the curve appeared. About 48 percent fell between 30 and 60 minutes, and 76 percent were completed within 1 hour. The mean time for field trips was 49 minutes but the modal interval was 45 minutes.

As shown in Fig. 3, B, the 3 and 4 minute records of hive stays by nectar carriers comprised nearly 40 percent of the total number recorded in 1920. Over 75 percent were completed within 10 minutes. The average time for all hive stays was 11.6 minutes but the figure is not very significant owing to the markedly skew form of the curve. The modal or most frequent interval spent in the hive between field trips was 3.9 minutes.

In 1921, the records of hive stays were more widely scattered than in the preceding year. The peak of the curve fell within the 5-6 minute period which included only about 23 percent of the records; but nearly 68 percent were completed in 10 minutes or less. The mean time was about 16 minutes while the modal interval was 5.5 minutes.

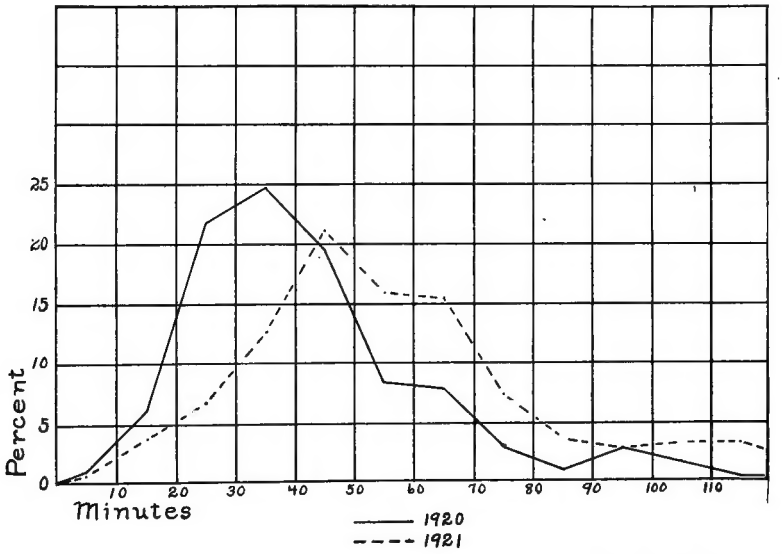

Fig. 4. Showing the frequency distribution of time records for round trips made by nectar carriers under *favorable* and *unfavorable* honeyflow conditions.

Nearly 25 percent of the round trips recorded for 1920 fell within the 31-40 minute period as shown in Fig. 4. Just 66 percent occupied between 20 and 50 minutes each, and 90 percent were completed in less than 1¼ hours. The mean time was 45 minutes, whereas, the modal or most frequent time was only 35 minutes.

In 1921, about 21 percent of the recorded round trips belonged in the 41-50 minute class. Scarcely 50 percent fell between 20 and 50 minutes and only 80 percent were completed in less than 1¼ hours. The mean time was 63 minutes but the modal time was 46 minutes.

The maximum number of trips recorded in one day for a nectar carrier was 24 in 1920 and 17 in 1921. The average number of trips per day was found to be 13½ in 1920 while in 1921 the average was only 7 per day. If the mean time for round trips for each year be multiplied by the average number of trips per day for the same year, we arrive at an approximation to the average time per day spent in nectar gathering. This gives about 8½ hours for field work in 1920 and about 7½ hours for 1921.

Pollen Gathering

Time records for field trips, hive stays and round trips by bees gathering pollen from corn were secured in 1920 and again in 1921. The weather conditions in both instances were favorable enough for the production of pollen by the plant and for field work on the part of the bees. But in 1920, the data were taken at times when there was an abundance of corn in bloom, whereas, in 1921, the main period of bloom had passed before the records were obtained. We have, then, as for nectar carriers, one set of data secured under favorable conditions, and the other under less favorable conditions. The records for the two seasons have been plotted against each other in the form of frequency curves which appear in Fig. 5, A. B and C. In every case the curve is a decided skew, so for purposes of comparison, the *mode* is used in preference to the *mean*.

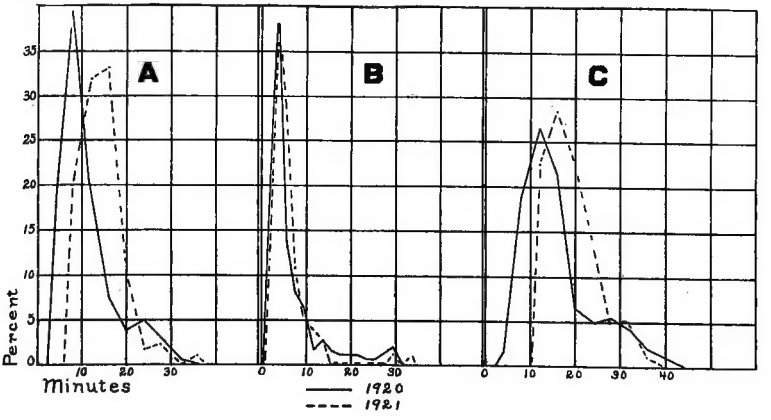

Fig. 5. Showing the frequency distribution of time records made by pollen bearers when gathering pollen from corn under *favorable* and *unfavorable* conditions. A, Field trip records. B, Hive stay records. C, Round trip records.